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AIR TRAVEL AND HEART DISEASE*

Physicians are not infrequently asked by patients with heart disease if it is "safe" for them to fly. By "safe" they usually have in mind their response to the stresses which might be encountered during flight. In most instances the question is readily answered because, in the absence of serious illness, the stresses are easily borne and the problem narrows down to one of passenger comfort. In the case of patients with serious illness their question should be answered only after a careful evaluation of their limitations in terms of travel stress. It is the purpose of this report to touch briefly on some of the important points in making such an evaluation. A little background is provided by the past experience of the commercial airlines in transporting passengers and of the military in transporting patients by air.

In the early days of commercial aviation it was feared that many passengers with heart disease might suffer en route. This fear was largely allayed as the result of an analysis published in 1941 which showed that out of a total of seven million passengers carried by five major airlines only three deaths occurred aloft. All three were ascribed to heart failure. In addition, five deaths were known to have occurred shortly after the passengers deplaned, and two of these deaths were considered to be of cardiac origin. The conclusion "if you can walk you may fly" was a good generalization which subsequent experience has confirmed in large part.

In June 1947 the Civil Aeronautics Administration requested the scheduled air carriers to supply information on all "incidents of death and unconsciousness" in flight. Data for the latter are complete for the years 1948-1950 and the information regarding fatalities is complete for the five year period 1947-1951.** The incidence of attacks of unconsciousness was 6 for every 100,000 passengers. The reported causes were "non-apparent" (41%); prior illness (18%); physiological or psychological, chiefly over-fatigue and emotional stress (18%); epilepsy (11%); cardiovascular (11%); and pregnancy (1%). A comparison was made between

the incidence of attacks in pressurized and non-pressurized cabins. The incidence was similar during 1950 but significantly higher for the non-pressurized type for 1948-1949. It is interesting that the "mean maximal altitudinal environment" was the same for both types of cabins in 1950 but significantly higher in the case of the non-pressurized for 1948-1950. The possibility exists that high altitude was a factor, but it must be remembered that, generally speaking, travel is more comfortable in the newer type of plane with pressurized cabins.

With regard to fatalities there was one death aloft for every one and one-half million passengers carried, and the leading cause was cardiovascular disease. A significantly greater number of deaths occurred in the non-pressurized type of cabin when compared with the pressurized type although altitudinal differences were insignificant.

Two important conclusions may be drawn from the Civil Aeronautics Administration report. First, the death rate and the number of attacks of unconsciousness during flight were very low. Second, the fact that these incidents were fewer in the pressurized than in the non-pressurized type aircraft is proof that flying stress is a factor, albeit small. Unfortunately, comparative data do not exist for other types of transportation.

The story of the transport of sick and wounded by air during World War II is one of the most remarkable in all military medical history. More than 1,500,000 patients, many desperately sick and wounded, were carried by the Army Air Force with fewer than 50 deaths. This, despite the fact that oftentimes there was little or no opportunity for selection.

* From the U. S. Naval School of Aviation Medicine, U. S. Naval Air Station, Pensacola, Florida. The opinions or conclusions contained in this report are those of the author. They are not to be construed as necessarily reflecting the view or the endorsement of the Navy Department.

** For this information, contained in an as yet unpublished report, I am indebted to the politeness of Dr. Barry C. King, Medical Division, Civil Aeronautics Administration.

TRAVEL STRESS

Although this discussion will be limited chiefly to specific stresses which might be encountered during flight on the regularly scheduled domestic airlines, it is important to mention certain additional factors which are not directly related to flying. These include (1) the trips to and from the airport, (2) the walk or climb on the ramps, (3) climbing aboard (the steps may number 15 or more), (4) the possibility of delay in take-off, (5) the possibility of missing a connecting plane if the scheduled time interval is short, and (6) the possibility of delay or landing at an alternate airport in the event of bad weather or other unfavorable conditions.

SPECIFIC FLIGHT STRESSES

Four important factors which have a qualifying influence on flight stress in increasing order of importance are (1) number of stops, (2) type of plane, (3) duration of flight, and (4) weather conditions. Information concerning the first three is readily obtainable, and their significance is obvious. Unfortunately, it is not always possible to obtain accurate weather predictions, especially in certain areas and during certain times of the year; hence, weather is an uncertain variable.

The specific stresses to be considered are due to (1) reduced atmospheric pressure, (2) acceleration, (3) noise and (4) danger.

Reduced Atmospheric Pressure.

Reduced atmospheric pressure may affect the body by (1) producing anoxia, (2) expanding free gases in the body, and (3) releasing gases which are in solution in blood or other tissue.

Anoxia — The civil air regulations, in addition to prescribing the maximum altitude of flight operation, state that supplemental oxygen shall be provided on each air carrier for flights of more than 30 minutes duration above 8,000 feet; progressively larger amounts shall be carried at progressively higher altitudes. Similar safeguards are also provided in the case of pressurized cabin airplanes when operating at flight altitudes above 8,000 feet. Ordinarily during flight the pressure altitude in such cabins is kept well below this level. Even at 8,000 feet anoxia is rarely a problem. The reason for this lies in the manner in which oxygen combines with hemoglobin, a chief characteristic of which is the lack of linearity between the fall in atmospheric pressure and the decrease in arterial oxygen saturation. Thus, at 8,000 feet, although the atmospheric pressure has fallen to about three-quarters of that at sea level, the corresponding decrease in arterial oxygen saturation is about 5 per cent.

Even this small stress is not obligatory inasmuch as it is usually possible to arrange for supplemental oxygen administration throughout the flight. The new "disposable" oxygen masks made of plastic are efficient and comfortable.

Body Gases — Free gases in the body expand and contract as a function of the changing pressure of the ambient air. Rate of change determines the magnitude of the stress. Sudden changes in pressure are deliberately avoided either by controlling the rate of climb and descent in the case of non-pressurized aircraft or by control of cabin pressure in pressurized planes. This control, however, has practical limits beyond which changes in pressure represent an obligatory stress. This may be sufficient to produce discomfort in susceptible individuals, in which case attention must be given to the factor causing the susceptibility, usually abdominal distention or obstruction of middle ear or sinus.

There is considerable individual variation in the ease with which persons "ventilate" middle ear and sinus and much variation from time to time in the same individual depending on such factors as infection and allergy. Postponement of a trip may be warranted if a person is suffering from an upper respiratory infection. If symptoms are anticipated during flight the judicious use of vasoconstricting drugs may be worthwhile. Earache is more likely during descent than ascent. Frequent swallowing helps and candy or gum stimulates the flow of saliva. The most valuable procedure is to attempt to exhale through the nose while holding the nostrils closed.

Abdominal distention due to expansion of gases rarely causes much distress, but patients with this tendency should avoid eating gas-forming foods prior to travel.

Bends — Decompression sickness or bends, due to a rapid decrease in atmospheric pressure, which releases nitrogen normally held in solution, is not a problem in flights below 25,000 feet. Hence, it is not encountered in commercial aviation save in the rare event of sudden decompression in the case of pressurized aircraft flying above this altitude.

Accelerations.

The air traveler is subjected to two types of accelerative forces. Angular acceleration is generated during rotation of the plane about one or more of its principal axes (pitch, roll, and yaw) and produces its principal effects by virtue of stimulation of the semicircular canals; this, in turn, is probably the chief cause of motion sickness. The second type of accelerative force is generated during a change in speed of direction

SCIENTIFIC PROGRAM
Presented by
SECTION ON CLINICAL CARDIOLOGY
AMERICAN HEART ASSOCIATION
Conrad Hilton Hotel, Chicago, Illinois
April 3-4, 1954

ASSEMBLY PANELS

10:00 A.M. and 2:30 P.M., Thursday, April 1

ASSEMBLY MEETING

9:00 A.M., Friday, April 2

**RHEUMATIC FEVER PROGRAM — DEMONSTRATION AND PANEL,
COUNCIL ON RHEUMATIC FEVER AND CONGENITAL HEART DISEASE**

2:00 P.M., Friday, April 2

ANNUAL DINNER OF THE AMERICAN HEART ASSOCIATION

7:30 P.M., Saturday, April 3

FIRST MEETING

9:00 A.M., Saturday, April 3

Chairman: A. Carlton Ernstene

1. **METABOLISM OF MYOCARDIUM.**
W. F. H. M. Mommaerts, Cleveland, Ohio.
2. **VALUE OF ROUTINE TESTING OF HYPERTENSIVE PATIENTS FOR PHEOCHROMOCYTOMA.**
David C. Humphrey and A. Carlton Ernstene, Cleveland, Ohio.
3. **TRAUMATIC AORTIC ANEURYSMS.**
Edwin M. Goyette, Hu A. Blake, James H. Forsee and Henry Swan II, Denver, Colorado.
4. **LOWERING OF SERUM CHOLESTEROL BY THE ADMINISTRATION OF PLANT STEROLS.**
Maurice M. Best, Edward J. VanLoon, Charles H. Duncan and Joan D. Wathen, Louisville, Kentucky.
5. **THE LONG TERM PROGNOSIS FOLLOWING MYOCARDIAL INFARCTION.**
Louis N. Katz, David R. Cole and Evelyn B. Singian, Chicago, Illinois.
6. **THE SPATIAL VECTORCARDIOGRAM IN ACUTE CORONARY INSUFFICIENCY AND ACUTE MYOCARDIAL INFARCTION.**
Richard S. Cosby, John Talbot, David C. Levinson and George C. Griffith, Pasadena, California.
7. **PANEL DISCUSSION: CARDIAC ARRHYTHMIAS.**
Howard B. Sprague, Moderator.

SECOND MEETING

1:30 P.M., Saturday, April 3

Chairman: Wright R. Adams

8. **ADVANCES IN THE SURGICAL TREATMENT OF ARTERIAL DISEASE.**
Norman E. Freeman, San Francisco, California.
9. **DOES MITRAL STENOSIS RECUR AFTER COMMISSUROTOMY?**
Robert P. Glover and Thomas J. E. O'Neill, Philadelphia, Pennsylvania.
10. **THE RELATIONSHIP FOLLOWING MITRAL COMMISSUROTOMY OF CARDIAC FINDINGS TO SO-CALLED FUNCTIONAL RESULTS.**
Louis A. Soloff and Jacob Zatuchni, Philadelphia, Pennsylvania.
11. **ANALYSIS OF SUCCESSES AND FAILURES AFTER MITRAL VALVE COMMISSUROTOMY.**
Robert L. Grissom, Luke Pascale, Angelo P. Creticos and Louis A. Selverstone, Omaha, Nebraska.
12. **CLINICAL APPRAISAL OF IMMEDIATE AND LATE HEMODYNAMIC EFFECTS OF MITRAL COMMISSUROTOMY.**
R. L. Parker, H. B. Burchell, E. H. Wood and John W. Kirklin, Rochester, Minnesota.
13. **LEFT ATRIUM PRESSURE PULSES IN MITRAL VALVE DISEASE.**
Don L. Fisher, Theron B. Childs, William B. Ford and Edward M. Kent, Pittsburgh, Pennsylvania.
14. **PANEL DISCUSSION: PREVENTION OF COMPLICATIONS OF MYOCARDIAL INFARCTION.**
George C. Griffith, Moderator.

THIRD MEETING

9:00 A.M., Sunday, April 4

Chairman: Wright R. Adams

15. ANGIOCARDIOGRAPHY.

Charles T. Dotter, Portland, Oregon.

16. VALVULAR PULMONIC STENOSIS. CLINICAL AND PHYSIOLOGIC RESPONSE TO OPEN VALVULOPLASTY.

S. Gilbert Blount, Jr., Malcolm C. McCord and Henry Swan, Denver, Colorado.

17. PULMONARY ARTERIAL HYPERTENSION WITH MARKEDLY INCREASED PULMONARY RESISTANCE. THE PULMONARY VASCULAR OBSTRUCTION SYNDROME.

Alexander S. Nadas, Joseph G. Cutler and Walter T. Goodale, Boston, Massachusetts.

18. DIAGNOSIS AND TREATMENT OF THE "MALIGNANT" TYPE OF PATENT DUCTUS ARTERIOSUS IN INFANTS. A CLINICAL, ANGIOCARDIOGRAPHIC AND CARDIOPHYSIOLOGIC STUDY OF TWELVE PATIENTS.

Benjamin M. Gasul, Egbert H. Fell, Carl J. Marienfeld and Robert F. Dillon, Chicago, Illinois.

19. MARFAN'S SYNDROME: A STUDY OF THE CARDIOVASCULAR ASPECTS IN ABOUT 50 AFFECTED KINSHIPS WITH A TOTAL OF OVER 100 AFFECTED INDIVIDUALS.

Victor A. McKusick, Baltimore, Maryland.

20. PANEL DISCUSSION: PATHOGENESIS OF ATHEROSCLEROSIS.

Edgar V. Allen, Moderator.

21. BUSINESS MEETING — SECTION ON CLINICAL CARDIOLOGY.

FOURTH MEETING

1:30 P.M., Sunday, April 4

Chairman: A. Carlton Ernstene

22. ANTIBIOTIC THERAPY OF BACTERIAL ENDOCARDITIS. V. SUBACUTE ENTEROCOCCAL ENDOCARDITIS: CLINICO-PATHOLOGICAL AND THERAPEUTIC CONSIDERATIONS OF 30 CASES.

J. E. Geraci, W. J. Martin and J. M. Needham, Rochester, Minnesota.

23. PRESENTATION OF LASKER AWARD TO A. SZENT-GYÖRGYI BY IRVING S. WRIGHT.

24. LEWIS A. CONNER LECTURE: AN INTRODUCTION TO ATHEROSCLEROSIS.

Irvine H. Page, Cleveland, Ohio.

25. MICROSOUND ANALYSIS OF HEART SOUNDS AND MURMURS AS A DIAGNOSTIC AID.

Simon Rodbard, Chicago, Illinois.

26. THE RELATIONSHIP OF CARDIOVASCULAR AND RENAL FUNCTION TO THE FORMATION OF EDEMA IN CONGESTIVE HEART FAILURE.

William Hollander and Walter E. Judson, Boston, Massachusetts.

27. COR PULMONALE, POLYCYTHEMIA AND HEART FAILURE.

Hans H. Hecht, Walter R. Gaylor and David H. Stein, Salt Lake City, Utah.

28. PANEL DISCUSSION: ELECTROLYTES AND HEART FAILURE.

J. Russell Elkinton, Moderator.

of the plane and forms a resultant vector with the force of gravity. In commercial aviation the magnitude of these forces is not great and the problem of blackout, etc., does not arise. However, in turbulent air, short-lived linear accelerations, sometimes resembling those experienced in elevators, may contribute to motion sickness. Deleterious effects of buffeting are satisfactorily prevented by means of seat belts except insofar as they may contribute to fatigue.

Thus, it may be concluded that motion sickness is the one important problem related to the accelerative forces experienced during flight on commercial airliners. The stresses responsible for motion sickness are partly under operational control; for example, large aircraft flying "over or around the weather" subject the passenger to less stress than smaller craft flying in turbulent air. Preventive measures should always be taken in the case of those who are susceptible. The following hints may be useful: (1) the tendency to motion sickness is less in good weather than in bad; at night compared to daytime; and at high compared to low altitude, (2) seats in the center are preferable to those at the ends of the cabin, (3) insofar as possible the head should not be moved and the eyes should be kept closed, (4) dramamine 100 mg. prior to flight and every 4 hours thereafter is helpful in a large percentage of cases; hyoscine hydrobromide gr. 1/100 is equally good.

Vibration and Noise.

Vibration might properly have been considered as one of the effects of acceleration but it is usually discussed separately. Both vibration and noise vary according to the type of plane and are important because they contribute to fatigue.

Danger.

The fatality rate for the scheduled air carriers is approximately 8 times that for the railroads and bus lines but only 2/3 that for travel by automobile. Thus, an explanation for the fact that persons unafraid in a car are fearful in a plane must be sought elsewhere than in the safety record. These fears are largely traceable to the dramatic and awful consequences of a crash, to inexperience, and lack of familiarity not only with flying *per se* but with the skills of pilot and navigator which make it possible. The "first-timer" especially may be apprehensive at hurtling through a dense overcast or rain storm, on observing streaks of oil on the engine nacelle or sparks from the exhaust stack, or on hearing the change in sound when the engines are throttled back on reaching altitude. Whatever the causes,

the net result may be anxiety or fear to a degree which has an unfavorable effect on the cardiovascular system. Prevention lies in reassurance insofar as the fears are unwarranted and in the use of sedatives.

Thus, in attempting to evaluate overall travel stress, it is essential to consider in detail every step of the journey. With regard to the inflight portion of the trip, the type of plane, flight plan, and weather conditions have an important modifying influence on the specific flight stresses. The chief symptoms which the passenger may experience are related to anxiety, motion sickness, obstruction of middle ear or sinus, anoxia, and fatigue. Much can be done in cooperation with the flight attendant to prevent or relieve them.

An attempt has been made in Table 1 to rank some of the important factors and arrive at a score by which the severity of flight stress can be graded from I to III. This is put forward, despite feelings of diffidence, because of the necessity of arriving at some concrete estimate of the travel stress involved. A chief difficulty in the whole problem of evaluation lies in the uncertainties still associated with air travel. A change in operational conditions, which might occur subsequent to take-off, could change flight stress from Grade I to Grade III.

THE MEDICAL EXAMINATION

It is essential to carry out a fairly comprehensive medical examination even though the chief emphasis is placed on the cardiovascular evaluation. It is not within the scope of this report to discuss in detail how this might be done but a few suggestions may serve to indicate points for emphasis.

Patients fall into three categories with respect to their ability to withstand flight stress. The first, Group I, comprises those for whom even Grade III flight stress is not hazardous. The second, Group II, consists of those for whom the flight stress is a calculated risk; the risk being proportional to the grade of flight stress. In the third category, Group III, are those patients who are unable to withstand even Grade I flight stress without serious risk of permanent injury or even danger to life. The chief factors which differentiate patients with heart disease into these three groups have been listed in Table 2. Just as in the case of grading flight stress this categorization must be regarded as a rough approximation.

Patients in Grades I and II, as determined from their cardiac evaluation, may require upgrading on the basis either of their tendency to anxiety, motion sickness, and earache or some complicating illness. The important complications include anemia (hemoglobin below 10

gms.), convalescence from severe illness or operation, diabetes if poorly controlled, epilepsy, exhaustion, peptic ulcer if active or bleeding, pulmonary disease and pneumothorax, pregnancy if complicated or near term, and psychoses.

FINAL APPRAISAL

In the case of patients in Group I the only problem is that of passenger comfort and the physician may be able to make helpful suggestions which either reduce the stress or mask its effects. The calculated risk for the patients in Group II depends on the grade of flight stress. Where the risk is considerable, two further questions arise (1) whether the trip is a matter of necessity or convenience, and (2) whether some other mode of travel is to be preferred. If the

trip is deemed to be necessary, and this also applies to patients in Group III, the advantages and disadvantages of all possible modes of travel must be considered and compared. In the case of travel by ship, train, bus, and automobile the advantages and disadvantages are known to nearly everyone as a matter of common experience. The principal advantages of flying are the speed of travel, the assurance of a comfortable seat in air conditioned environment, and the services of a flight attendant. The principal disadvantages are the unpredictability of the grade of flight stress and the effect of these stresses on the patient. Air ambulance is sometimes a possibility.

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The opinions and conclusions expressed herein are those of the author and do not necessarily represent the official views of the Scientific Council of the American Heart Association.

Table 1. FACTORS DETERMINING SCORE FOR GRADING THE SEVERITY OF FLIGHT STRESS.

	SCORE		
	1	2	3
Trip to or from airport	longer than 1 hour		
Length of ramp	less than 1 block	more than 1 block	
Height of stairs	5-10 steps	more than 10 steps	
Duration of flight	less than 3 hours	3-7 hours	
Flight plan*	ideal	good	fair
Weather conditions	good	fair	poor
Other factors			

Subtract 1 from total score if plane has 4 engines. Subtract 2 if cabin pressurized.

Flight stress is Grade I if final score 4 or less; Grade II if 5-8 and Grade III if 9-12.

* The flight plan includes such variables as number of stops, transfers, season of year, nature of terrain, and pressure altitude, etc.

Table 2. CLASSIFICATION OF PATIENTS ACCORDING TO THEIR ABILITY TO WITHSTAND FLIGHT STRESS

		Group I	Group II	Group III
Cyanosis	Congenital	slight	moderate	marked
	Other	none	slight	moderate or more
Attacks due to arrhythmia		able to walk	unable to walk	severe shock or unconsciousness
Heart size		slight enlargement	moderate enlargement	great enlargement
Valvular stenosis		moderate	marked	extreme
Infarction		healed; minor residua	healed; major residua	impending or resolving
Hypertension		under 220/120 without complications	with retinitis and kidney failure	hypertensive encephalopathy
Anginal failure		none	on effort	angina decubitus
Congestive failure		none	slight	moderate or more
Cardiac reserve		one flight without difficulty	one flight with difficulty	cannot climb one flight

